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Request for grant of a patent

(See the notes on the back of this form. You can also get an explanatory leaflet from the Patent Office to help you fill in this form)

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1.	**Your reference**	31.32.80134/004
2.	**Patent application number** *(The Patent Office will fill in this part)*	0407601.4
3.	**Full name, address and postcode of the or of each applicant** *(underline all surnames)*	Pelikon Limited Trecenydd Business Park Caerphilly Wales CF83 2RZ
	Patents ADP number *(if you know it)*	08337792002
	If the applicant is a corporate body, give country/state of its incorporation	
4.	**Title of the invention**	Improved Displays
5.	**Name of your agent** *(if you have one)*	Frank B. Dehn & Co.
	"Address for service" in the United Kingdom to which all correspondence should be sent *(including the postcode)*	179 Queen Victoria Street London EC4V 4EL
	Patents ADP number *(if you know it)*	166001

6. Priority: Complete this section if you are declaring priority from one or more earlier patent applications, filed in the last 12 month

Country	Priority application number *(if you know it)*	Date of filing *(day / month / year)*
United Kingdom	0318598.0	7 August 2003
United Kingdom	0319838.9	22 August 2003

7. Divisionals, etc: Complete this section only if this application is a divisional application or resulted from an entitlement dispute *(see note f)*

Number of earlier UK application	Date of filing *(day / month / year)*

8. Is a Patents Form 7/77 (Statement of inventorship and of right to grant of a patent) required in support of this request?
Answer YES if:
a) any applicant named in part 3 is not an inventor, or
b) there is an inventor who is not named as an applicant, or
c) any named applicant is a corporate body.
Otherwise answer NO (See note d)

~~No~~ Yes

9.	**Accompanying documents: A patent application must include a description of the invention. Not counting duplicates, please enter the number of pages of each item accompanying this form:**	
	Continuation sheets of this form	
	Description	11
	Claim(s)	
	Abstract	
	Drawing(s)	1 x1 SN
10.	**If you are also filing any of the following, state how many against each item.**	
	Priority documents	
	Translations of priority documents	
	Statement of inventorship and right to grant of a patent *(Patents Form 7/77)*	
	Request for a preliminary examination and search *(Patents Form 9/77)*	
	Request for a substantive examination *(Patents Form 10/77)*	
	Any other documents *(please specify)*	
11.		**I/We request the grant of a patent on the basis of this application.** Signature Date 2 April 2004
12.	**Name, daytime telephone number and e-mail address, if any, of person to contact in the United Kingdom**	Robert Jackson 020 7206 0600

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Notes

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80134/004

Improved displays

This invention is concerned with improved displays, and relates in particular to displays, such as electroluminescent displays, that employ an overlayer to increase their actual or apparent contrast.

Certain materials are electroluminescent - that is, they emit light, and so glow, when an electric field is generated across them. The first known electroluminescent materials were inorganic particulate substances such as zinc sulphide, while more recently-found electroluminescent materials include a number of small-molecule organic emitters known as organic LEDs(OLEDs) and some plastics - synthetic organic polymeric substances - known as light-emitting polymers (LEPs). Inorganic particulates, in a doped and encapsulated form, are still in use, particularly when mixed into a binder and applied to a substrate surface as a relatively thick layer; LEPs can be used both as particulate materials in a binder matrix or, with some advantages, on their own as a relatively thin continuous film.

This electroluminescent effect has been used in the construction of displays. In some types of these a large area of an electroluminescent material - generally referred to in this context as a phosphor - is provided to form a backlight which can be seen through a mask that defines whatever characters the display is to show. In other types there are instead individual small areas of EL material. These displays have many applications; examples are a simple digital time and date display (to be used in a watch or clock), a mobile phone display, the control panel of a

household device (such as a dishwasher or washing machine), and a hand-holdable remote controller (for a television, video or DVD player, a digibox, or a stereo or music centre).

The visibility of electroluminescent displays is dependent upon the contrast between those areas of the display that are turned on ("lit") and those that are not; this contrast is the result of the lit areas being both brighter than the surrounding areas ("luminance contrast") and often also a different colour ("chrominance contrast"). The brightness and colour of the lit areas is a function of the particular electroluminescent material being utilised and of the degree to which it is energised. The brightness and colour of the unlit areas is dependent on the light reflected off their surface, which in turn is a function of the ambient light level and the materials used to make up the display (which might include filters and anti-reflective coatings).

As noted above, electroluminescent displays can utilise either a continuous back electrode or, instead, a plurality of individual appropriately-shaped back electrodes each supplied with the required activating voltage by a separate lead. This lead may itself activate the electroluminescent material, rather like a small electrode, and so can give rise to the relevant component of the display appearing to have a "tail". In the Specification of our co-pending Patent Application No: GB0318598.0 there are described and claimed a number of solutions to the "tail" problem. In one of these the colour/reflectivity of one or other of the electroluminescent material and the surrounding insulator material is modified - or is apparently modified - so as to match that of the other. And one of a number of techniques for achieving this (apparent) modification is to provide the display with a front filter/absorber layer of

suitably-coloured transparent material so as appropriately to modify the manner in which external light entering the display from the ambient surroundings is transmitted thereinto and then reflected back. This filter layer, the use of which apparently modifies the colour/reflectivity of one or other of the electroluminescent material and the surrounding insulator material so as to match that of the other, either can be a part of the substrate itself or, and preferably, it can be an additional layer formed on the substrate (and conveniently on the outside, front, surface).

The filter layer appropriately modifies how external light entering the display is then reflected back from the several interfaces - typically ambient air/filter, filter/substrate, substrate/phosphor and substrate/insulator. In this particular case what is required is that the light reflected off the very front of the display - the front of the filter - should be very much greater than the light reflected off any of the "internal" interfaces, and that the light reflected from the substrate/phosphor interface should match in colour and hue the light reflected from the substrate/insulator interface. And when the display - the phosphor - is "on" (activated), the output from the phosphor should be significantly greater than any reflected light (and especially that off the filter at the very front).

It will be seen that, using such a filter, emitted light from the phosphor makes one pass through the filter while reflected light from the ambient surroundings must make two passes through the filter, and so the resultant visibility of any pattern of phosphor is, in the "off" state, reduced by the ratio of the absorbency of the filter. Of course, the overall brightness of the display is also reduced, but

the ratio between the "on" state emissions and any of the various "off" state reflection levels is enhanced.

This effect can be further exploited if the reflectance spectrum of the filter is shifted in wavelength compared to the transmittance spectrum of the filter, so that the colour/hue of the emitted light from the phosphor is not the same as that of the reflected light from the very front - the filter - surface of the display. While this does not provide an improvement in light intensity terms nevertheless it improves visibility through chrominance contrast.

A suitable material colour for such a filter, providing the desired effect, is that deep blue provided by Ultramark under the designation 575/T134402.

In the Specification of our co-pending Patent Application No: GB0319838.9 there are disclosed additional methods of applying the above mentioned solutions. The present invention relates to further additional methods. More specifically, there is now first proposed the use not of a coloured filter but instead of the very opposite - a neutral density filter (that is, a filter which, "grey" in appearance, filters out all colours uniformly). And in addition there is also proposed a "filter" layer which has a specularly-reflective front (exterior) surface (typically such a layer is, like a one-way mirror, semi-silvered, so as to be highly reflective from one side (the outside) but significantly transmissive from the other side (the inside).

In one aspect, therefore, this invention provides a light-emitting display wherein there is the necessity for a clear contrast between the display's lit and unlit areas, which display includes a transmissive overlay that forms either a substantially-neutral-density filter or an outwardly-facing specularly-reflective surface, or both.

The light-emitting display can be of any sort - it could, for instance, be a light-emitting diode (LED) display, or it could be a backlit liquid crystal display (an LCD) or even a thin film transistor (TFT) display as used in computer screens - but the invention is of particular value when applied to displays using electroluminescent materials to provide the light output.

Electroluminescent (EL) displays are valued for their flexibility and thinness, which means they can be cut to any shape, operate on curves or be laid over button mats (operating as the display flexes when the button is pushed through the display).

Making a display remain hidden until there is some necessity for it to be revealed (and so seen by the User) is desired so that the display be uniformly blank until a segment is switched on, when it becomes visible. A unique feature of EL displays is that the light emanating from a switched on segment comes, as far as an observer is concerned, right from the surface of the display. However, as observed above many existing types of EL display are not ideal, in that much of the details of the display - such as the connection tracks into the segments and other structures - are visible. As the display is surface emitting, and due to the thinness of the display, observers tend to see these "off" elements (the inactive or non-active ones), which thus have the effect of reducing the visibility of the "on" (active) segments.

To make the "on" segments more apparent it has been traditional either to increase their brightness or to operate the display in a dim environment. The latter option severely limits EL displays, as many applications are for the display to be mounted directly onto the surface of a product that may

be in a bright daylight environment. Increasing the display's emitted brightness is possible, but has a severe disadvantage in that it may significantly reduce the lifetime of the display (and also run down any battery power source used to drive the display), and is in any case a losing battle for displays used in high intensity environments (where, in essence, the display is trying to outshine the ambient sunlight!). Most emissive technologies are unable to do this with acceptable reliability and lifetime.

The present invention - which involves the use of a transmissive overlay that forms a neutral-density filter and/or an outwardly-facing specularly-reflective surface - results in both the suppression of visibility of any connecting tracks and the display's internal structure and also an improvement to the visibility of the display's "on" segments compared to background scattered ambient light from the "off" elements of the display by what seems at first to be the rather bizarre idea of actually making the display dimmer. However, it works - and this is believed to be for the following reasons.

When using a neutral-density filter, suppression of the internal display structure - elements which are either unactivatable or are activatable but "off" - is achieved by reducing the intensity of the light reflected from such elements in comparison to the light emitted by the "on" segments. A thin, highly-absorbing, neutral layer placed over the display allows light from the emitting element to pass therethrough only once, and so is attenuated only once. However, light exiting from the structural elements and the "off" segments of the display, both of which only reflect ambient light, has passed through the absorbing layer twice. The contrast between the two lights is thus enhanced, even though the light from the "on" elements is reduced somewhat.

The visibility of the "on" elements increases - in comparison to all the other areas of the display - as the absorption of the overlay increases. This leads to the bizarre, intuition-contrary position that the brighter the environment the more absorbing the layer needs to be to achieve high visibility. The limit to how absorbing this overlay can be is determined by the point at which the light emitted by the "on" segments falls below the general background illumination of the environment in which the display is used, and so cannot be distinguished by the observer.

The display utilises a substantially-neutral-density filter. Strictly, and in theory, a true neutral-density filter is one that filters - that absorbs - all light frequencies equally. In practice, however, such perfect neutrality is not easily achieved, or achievable. Most filters commonly accepted as being neutral-density can show a difference, in some cases of as much as 20% - between the highest and lowest absorption across the range of the visible light spectrum. Thus, for the purposes of the present invention the term "neutral-density" includes such a frequency-dependent case - though it is naturally preferred that the difference be as small as possible.

Neutral-density filters vary - in appearance - from black through charcoal grey up to the very lightest grey, as the amount of light they absorb reduces. For the invention, in a real environment the absorption effect of the neutral-density filter used in the invention may conveniently be from 75 to 85%, and is most preferably around 80% (so that the emitted light is reduced to 20% of its original intensity while the reflected light is reduced to a further 20%, being a mere 4% of the ambient light level). Typical materials providing this sort of absorption together

with the right degree of flexibility and thinness are CP Films AT15GR HPR and Bekaert Black type NR Charcoal 17.

A specularly-reflective layer works in a different manner. Another factor that reduces the visibility of the "on" segments is the light reflected from the top - the outer - surface of the display. This is a significant issue for a surface-emitting display, as the light from the "on" segments within the display emanates from the same (or very nearly the same) plane as reflected light from the front face of the display. By contrast, other types of display avoid this problem because they have depth - the "on" portions are clearly significantly "below" the front surface of the display - and the eye/brain combination concentrates on the plane of the emitted light from the segments, and ignores the light reflected from the front of the display (a technique similar to "pulling focus" as used in photography). Another technique for avoiding surface reflection effects is to use expensive and often brittle anti-reflection coatings. However, neither technique - "deep" light-emitting elements, and anti-reflection coatings - is appropriate for surface-emitting EL displays that typically are required to be both low cost and also flexible. This part of the invention uses the surprising step of actually increasing the reflectivity of the surface layer by using a gloss finish.

Using an overlay having a specularly-reflective surface works by directing the light in specific directions and not scattering it. Thus, the eye can image the "on" segments on the surface of the display, which then means that all other specularly-reflected light is out of focus and so has minimal effect on the display's "on" segment visibility.

If the light source that is specularly reflected is very bright even when it is not in focus, such as the sun, the "on" segments can become visible to the User simply by slightly tilting the display so the bright object is specularly reflected somewhere other than back to the User.

This implementation of the invention can be effected just by having a very smooth - a "gloss" - finish to the front surface of the display, and the two neutral-density filter materials mentioned above do indeed have a high gloss, shiny, surface, providing the required specularly-reflective effect. However, in one extreme, and preferred, case an additional coating is provided on the outer surface to give a more truly reflective material, such as a metallic finish, showing a "silvered" or "chromed" effect.

In the case where the display is viewed normal to the User, only the light reflected from his or her face and impinging on the display is reflected straight back to the User. This is usually of a much lower intensity than the ambient light, but is also out of focus as apparently it is as far behind the display as the User is in front, and so has minimal effect on display visibility.

Reflective surfaces vary in the amount of light they reflect. In a real environment the reflective effect of the specularly-reflective overlay used in the invention may conveniently be from 75 to 85%, and is most preferably around 80%. Typical materials providing this sort of reflection together with the right degree of flexibility and thinness are CP Films RS20SR HPR (which is a plastics sheet with a sputtered metallised finish plus a gloss protective overlay.

Embodiments of the invention are now described, though by way of illustration only, with reference to the accompanying diagrammatic Drawings in which:

Figure 1 shows a display having a neutral filter overlay according to the invention; and

Figure 2 shows a display having a specularly-reflective filter overlay according to the invention.

In Figure 1 there is shown part of a display device (generally 11) having a multilayer display (12: only part of this is visible). The display 12 includes a display layer (13), in which is a display element (14: shown in it's "on" state) surrounded by other, structural, material (15), on top of which is a transparent protective layer (16). Overlying this is an outer layer (17) of neutral-density filter material.

Light coming from the display device towards the User - the eye - is a mixture of ambient light (18) and generated light (19); the reflected ambient light 18 is light that has first impinged upon the display from outside, then been transmitted through the filter layer 17, with attenuation, and through the transparent protective layer 16, and has then been reflected off the display material 15 and - with further attenuation - back out through the layers 16 and 17. By comparison, light emanating from the "on" display element 14 has travelled only once (with some attenuation) through the filter layer 17.

It will be apparent that the use of the filter layer 17 has significantly increased the display contrast - the intensity difference between the emitted element light and the reflected ambient light.

Figure 2 shows the use of a specularly-reflective overlay in accordance with the invention. It shows a display device (generally 21) viewed under strong ambient light. It will be evident that the ambient light (from the source 22 positioned off to one side) is - because of the specular nature of the front surface of the display device - all reflected off to the other side, none of it being directed towards the

User. It will also be apparent that any image of the User (caused by him or her being reflected in the reflective layer 22) is, far behind the device, well out of the plane on which he/she focuses to see the display, and so should not be troublesome.

Any light (23) from an ambient source directly behind the User is, of course, blocked by the User's head, and so is not seen.

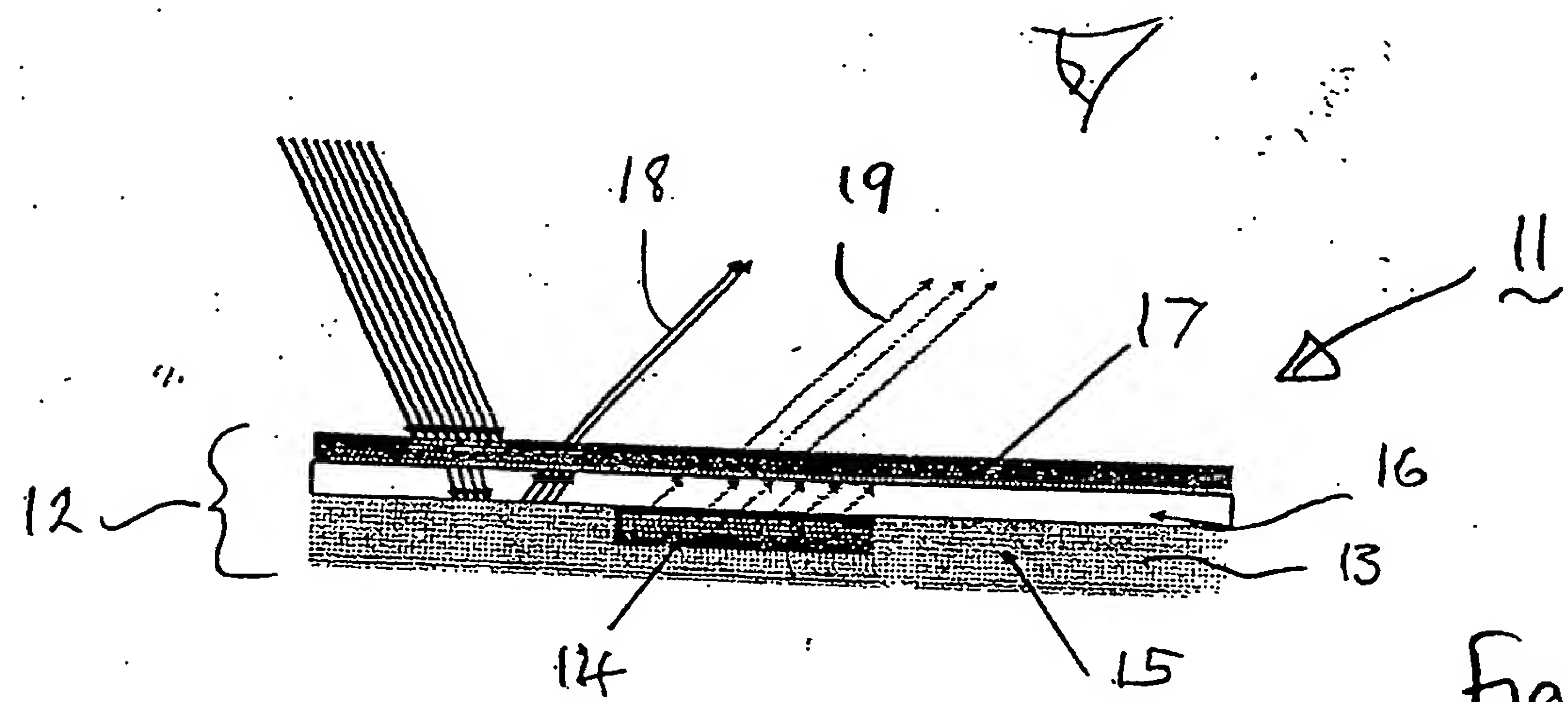

Fig 1

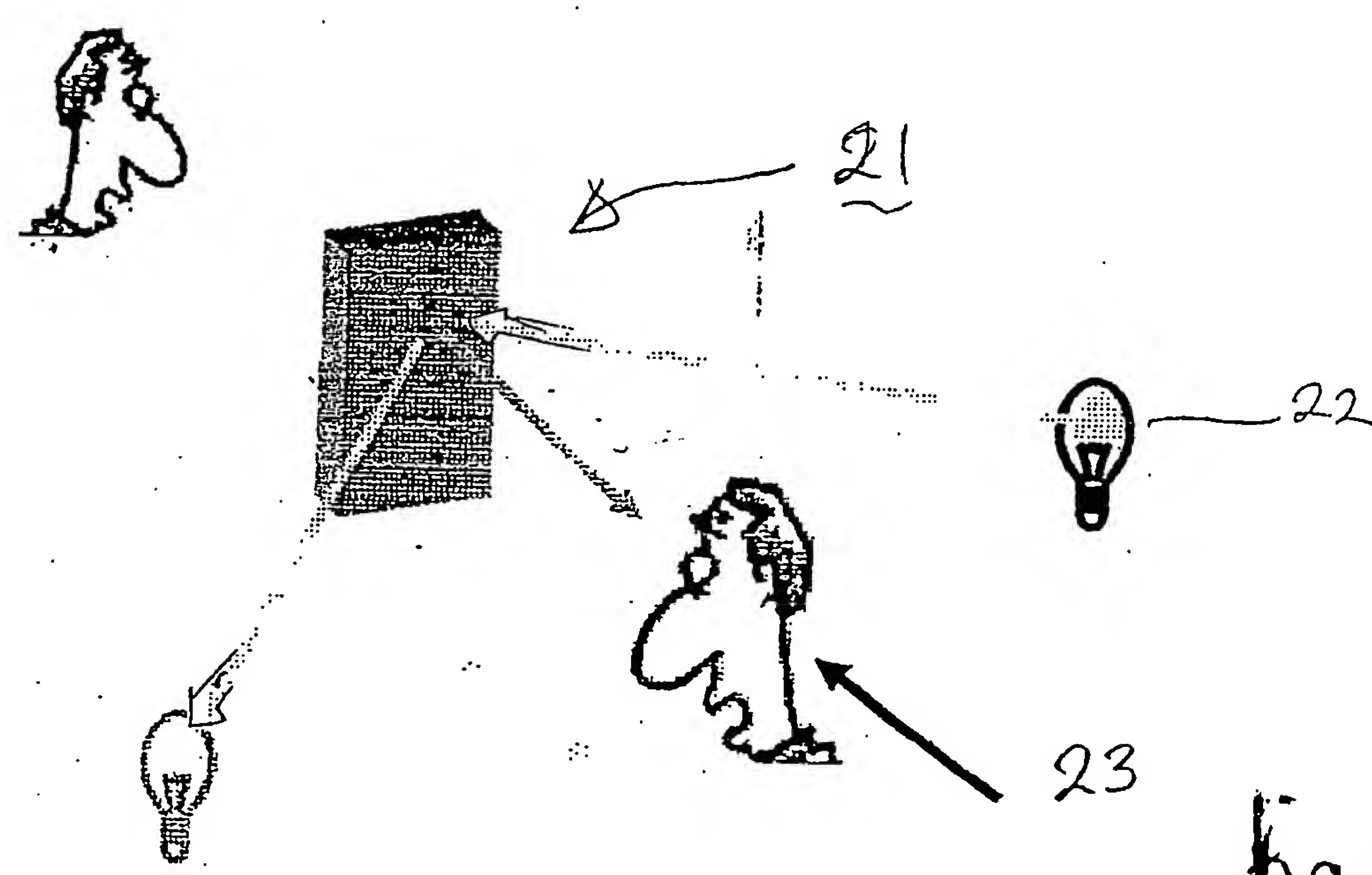

Fig 2

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